METHOD AND SYSTEM FOR THE DYNAMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMUNICATION NETWORKS

Field of the Invention

The present invention relates to a method for the dynamic allocation of radio channels in digital telecommunication networks, in particular with time division duplex access or TDD (*Time Division Duplex*), such as for instance mobile telecommunication networks belonging to DECT or UMTS-TDD standards. The present invention relates also to a system implementing this method.

It is well known that in mobile telecommunication networks with TDD access, the transmission and reception of radio signals from and to the base stations do not occur at the same time, but are alternated in a continuous sequence of periods having pre-determined duration, each of them called *frame* and opportunely coded and identified by the system. In particular, each frame is divided into a pre-determined number of time intervals or *timeslots*, they too having pre-determined duration, part of which is destined to transmission and part to the reception of the signals from base station to user equipment. Each one of these timeslots can also be subdivided into a plurality of *codes* representing the elementary resources (channels) assigned in the communication.

At each communication service between a mobile unit and a base station one or more channels of a particular time slot are generally assigned, which contains at most Nmax channels, according to the requested transmission speed.

Background art

Patent application WO 98 24258 A, assignee TELEFONAKTIEBOLAGET LM ERICSSON, discloses an "ADAPTIVE CHANNEL ADAPTATION METHOD FOR MULTI-SLOT, MULTI-CARRIER COMMUNICATION SYSTEM. The claim 1 testually recites:

" 1. In a communications system in which communications from a link transmitter to a link receiver are transmitted pursuant to a multi-slot communication scheme over subset of a set of a plurality of channels available to a link, a method of allocating channels for communications on a link, said method comprising the steps of:

– allocating a plurality of channels from said set to provide said subset;

– measuring a received signal on each channel of said set;

– determining if at least one unused channel exists in said set that is more preferred for use on said link than a channel of said subset; and

AMENDED SHEET

2

— reconfiguring said subset in response to an affirmative determination".

The measures performed on the second step are periodic measures of the quality C/I of the channels within the subset and the interference level of all the N available channels of the set. For the aim of best evaluating the condition of the channels also the level of multipath fading is measured upon channels upon which signals are transmitted downlink to the mobile station. A mobile station can avails itself from all the M channels of the subset except for the channels already in use to other mobile stations in the cell. The criteria adopted to allot a sorted channel to a service requester is that to allocate the least interfered channel placed at the top of the list to the first user which requests to be served and the remaining channels to the successive requesters ordered in the time. Channel allocation doesn't request any gender of measure on the requesting signal and doesn't involve any rearrangement of the channel priorities. The main drawback of the allocation method disclosed in the cited patent application is the absence of any suitable criterion to submit the allocation of a channel to the distance from the service requester to the Base Station, so that could reasonably happen that the nearest user receives the least interfered channel and the farthest user receives the most interfered channel, although intermediate situations are most realistic. As known, in any radiomobile system the ability to have channels with good quality depends on the skill to transmit with low power. The underlined drawback of the allocation mechanism doesn't allow a generalized power reduction overall in the system, in consequence of that the spectral efficiency is not improved.

Another example of a dynamic channel allocation procedure based on priority values Pi calculated for each timeslot is disclosed in the article by Y. Furuya and Y. Akaiwa under the title "Channel Segregation, A distributed Adaptive Channel Allocation Scheme for Mobile Communication Systems", Second Nordic Seminar on digital Land Mobile Radio Communication, 14-16 October 1986", pp 311-315. In the procedure of this second citation a control processor of the base station performs at each service request, a calculation of the priority values Pi on the basis of interference and/or quality measures of the channels, so that the timeslots available for the allocation of channels result only those whose priority value is higher than a given pre-set threshold value Pt. The calculation of priority values Pi of each timeslot after k service requests is generally made through the following iterative formula:

$$Pi(k) = \frac{Ns_i(k)}{k} = \frac{\sum_{a=1}^{k} s_i(a)}{k} = \frac{k-1}{k} Pi(k-1) + \frac{s_i(k)}{k};$$

AMENDED SHEET

where k is the number of connection service requests from the moment of system starting, $Ns_i(k)$ is the number of successful connections and $s_i(k)$ is a logic function returning 0 or 1 on the basis of the negative or positive result of the connection, respectively.

Observing such formula, it can be noticed that at starting, with small k values, the calculation of priority values very quickly adapts to the network characteristics, but results slowed when k values increase, therefore the above mentioned method known for the allocation of channels shows a high risk for connection losses in case the network traffic distribution suddenly changes, for instance when number of connection service requests occur, concentrated in time.

Summary and scope of the invention

Object of the present invention is therefore that to give a method for the dynamic allocation of channels which is free from this drawback, as well as a system implementing this method. Said object is attained with a method and a system whose main characteristics are specified in claims 1 and 12, respectively, while additional characteristics which are believed to be novel are specified in the appended claims.

The quality of channels allocated through the method according to the present invention is generally better compared to that of the channels allocated through the known methods. In fact, at equal number of allocated channels, the services with signals having higher attenuation values or "path loss" are allocated in timeslots having higher priority values, so that the allocated channels can be shared in the different timeslots in the best way according to the quality of the relevant signals. The peculiar allocation mechanism of the present invention allows to lower the power requirements for those users which need higher transmission power to counterbalance the pathloss due to their geographical penalty. The general power reduction further reduces the distance of reuse and increases the spectral efficiency consequently.

Another advantage of the present invention due to the allocation mechanism is the minimization of the so-called near-far effect, improving the performance of data detection in UMTS systems.

Furthermore, the method according to the present invention results much more rapid than the known methods, since a partial re-ordering of channels allocated in the different timeslots is made, that is, at each service requests, only the services employing the same number of channels of the requested service are re-ordered.

Another advantage of the method according to the present invention is represented by the use of a new kind of formula for the calculation of priority values which, contrarily to the above mentioned formula of the known type, enables to discretionary adjust the

AMENDED SHEET

4

system adaptation speed to the contingent situation of the network traffic, that is to the interference and/or quality variations of the channels.

A further advantage of the method according to the present invention is represented by the fact that said allocation and release algorithms can be structured in such a way to give preference, if necessary, to the services employing a low or high number of channels.

<u>Brief description of figures</u>

The present invention together with further advantages and characteristics thereof may be understood by those skilled in the art making reference to the following detailed description taken in conjunction with the accompanying drawings in which:

- figure 1 shows a partial block diagram of a system implementing the method according to the present invention;

- figure 2 shows a flow chart of an allocation algorithm of an embodiment of the method according to the present invention; and

- figure 3 shows a flow chart of a release algorithm of an embodiment of the method according to the present invention.

<u>Detailed description of a preferred embodiment of the Invention</u>

Making reference to figure 1, It can be noticed that a system implementing the method according to the present invention includes in a known way, a plurality of base stations 1 belonging to a digital telecommunication network with time division duplex access, such as for instance a mobile telecommunication network belonging to the UMTS standard, which communicate through radio signals with a plurality of user equipment 2. One or more channels C_i of a timeslot T_i are generally assigned to each communication service S_i made by base stations 1 (only 8 timeslots T_i of communications originated by the user equipment 2 are shown in the figure, for representation simplicity). Furthermore, a univocal priority value P_i is assigned to each timeslot T_i which, however, can vary in time according to the result of a known formula of the type described above or of a new formula which shall be described here after. Said priority values P_i are based on interference and/or quality measures of communication channels C_i between base stations 1 and user equipment 2.

According to a preferred embodiment of the invention the interference and/or quality measures of channels are made measuring the "path loss", that is the attenuation of the signal transmitted by the user equipment 2. According to the invention, the communications with higher path loss are allocated in timeslots with higher priority P_i, that is in channels capable of ensuring a better transmission quality. On the contrary,

5

communications with lower "path loss" are allocated in timeslots with lower priority Pi, that is in channels capable of ensuring a lower quality.

Tentatively said situation has been represented in figure 1 where for each station 1 a first coverage area 3 and a second coverage area 4 are represented. In figure 1 it is assumed that users located in the coverage area 4 are more distant from the relevant base station 1 and therefore communications shall be reasonably characterised by a higher "path loss" (they shall therefore be assigned a timeslot having higher priority Pi), while the users in coverage area 3 are closer to the relevant base station 1 and therefore their communications shall be reasonably characterised by a lower "path loss" (they shall therefore be assigned a timeslot having lower priority Pi).

Now, making reference also to figure 2, we notice that an embodiment of the method according to the present invention includes an allocation algorithm, which is started for instance on the moment a mobile unit 2 requests a service Sx requiring the use of a given number Rx of channels Ci to a base station 1. The base station 1 measures the level and therefore the path loss PLx of the signal with which the mobile unit 2 has requested said service Sx on the receipt channel. On the basis of the path loss measured value PLx, the base station 1 attempts to allocate the Rx channels Ci in the timeslot having an increasing priority value Pi with the same attenuation PLx, in order that user equipment 2 transmitting signals having a high path loss use timeslots having a high priority value.

To this purpose, it is searched, starting from timeslots having higher priority values Pi, a timeslot Tx having Rx free channels Ci. If said timeslot Tx does not exist, the base station 1 refuses the requested service Sx to the mobile unit 2. If on the contrary said timeslot Tx is found, the base station 1 searches, if existing, a timeslot where at least a service employing Rx channels Ci is allocated among the timeslots with priority value Pi higher than that of the timeslot Tx. This search is made through a scanning based on a variable T cyclically decreased by one unit. If the variable T is zeroed, the requested service Sx is allocated in the timeslot Tx. If on the contrary a timeslot T is found where at least a service with Rx channels Ci is allocated a search is made among all the services employing Rx channels Ci and are in the same timeslot T, the service Sy showing the lower path loss PLm. At this point, the base station 1 compares the value of the lower path loss PLm found with that of the PLx path loss of the signal with which the mobile unit 2 has requested the service Sx to base station 1. If the PLx path loss value is lower than that of the PLm path loss, the requested service Sx is allocated in the timeslot Tx having Rx free channels Ci, otherwise it is allocated in the same the service Sy employing Rx channels Ci and showing the PLm path loss. In this

AMENDED SHEET

6

last case, since a service having Rx channels Ci in the timeslot T got free, the algorithm described up to now is reiterated starting from this last timeslot, which is then identified as timeslot Tx in the reiteration of the algorithm itself, that is Tx = T.

When the service Sx is released, for instance after the interruption of a communication between mobile unit 2 and base station 1 or due to the transfer of a communication between two base stations 1, it is possible to employ a release algorithm of essentially inverse type compared to the one described above to free the timeslots Ti with low priority values Pi.

Making reference to figure 3, we see that an embodiment of the method according to the present invention includes a release algorithm, which is started for instance on the moment at which a service Sx employing Rx channels Ci is released by a timeslot Tx. The base station 1 attempts therefore to allocate the Rx free channels Ci to a service Sy employing Rx channels Ci in the timeslot having the highest priority value Pi among those having lower priority value compared to that of the timeslot Tx. To this purpose, the base station 1 searches, if existing, a timeslot where at least a service employing Rx channels Ci is allocated, among the timeslots with priority value Pi lower than that of the timeslot Tx. This search is made through a scanning based on a variable T cyclically decreased by one unit. If said timeslot T is found, the service Sy characterised by the highest path loss amongst all the services employing Rx channels Ci in timeslot T is allocated in the timeslot Tx. In this last case, since a service having Rx channels Ci in the timeslot T has got free, the algorithm described up to now is reiterated starting from this last timeslot, which is then identified as timeslot Tx in the reiteration of the algorithm itself, that is Tx = T.

If the variable T is reset, the search can be terminated or, a service Sy employing a number of channels Ci lower than Rx newly searched among all the timeslots with a priority value Pi lower than that of the last timeslot Tx released. Said research is made through ad additional scanning based on a variable R cyclically decreased by one unit. Once this last variable is reset, the algorithm is terminated.

Other embodiments of the method according to the present invention can possibly include variants of said release algorithm, always started on the moment on which a service Sx employing Rx channels Ci is released by a timeslot Tx. For instance, instead of searching first the services Sy employing Rx channels Ci among all the timeslots having a priority value Pi lower than that of the timeslot Tx, to pass then to the search of services Sy employing a number of channels Ci lower than Rx always among all the same timeslots, it is possible to search the service Sy characterised by the maximum attenuation employing a number of channels Ci equal to or even lower than

7

Rx in all the timeslots having lower priority value Pi compared to that of the timeslot Tx. With this algorithm, active services can therefore be reordered according to PLx attenuation values and increasing priority Pi values, irrespective of the number of channels Ci they employ.

At each allocation and/or release of a service, the priority values Pi assigned to the timeslots Ti can be recalculated. In place of the known algorithm based on the formula

$$Pi(k) = \frac{k-1}{k} Pi(k-1) + \frac{s_i(k)}{k},$$

in another embodiment of the method according to the present invention it is possible to employ the following formula in which the past experience $Pi(k\text{-}1)$ and the current situation $s_i(k)$ maintain a constant weight during the time:

$$Pi(k) = \lambda Pi(k-1) + (1-\lambda)s_i(k),$$

where λ is a memory factor included between 0 and 1, which can be freely selected according to the weight one wants to assign to the past experience or to the contingent situation. It is therefore clear that if λ tends to 0 or to 1, the priority values Pi vary in a quicker or lower way, respectively, depending on the interference and/or quality measures of channels Cl by the base station 1.

A further development of this other embodiment can consist in calculating $s_i(k)$ not on the basis of the simple statistics of the successful connections compared to total connections, but on the basis of the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{max} - N_{used_i}(k)};$$

in which $N_{free\ i}(k)$ is the number of channels Cl which can be allocated with a good quality in timeslot i, N_{max} is the maximum number of channels (or codes) available per timeslot and $N_{used\ i}(k)$ is the number of channels currently already allocated in the timeslot i.

Other embodiments and/or additions of the present invention may be made by those skilled in the art without departing from the scope thereof as defined by the claims.

AMENDED SHEET

Empfangszeit 25.Okt 15:38